Analysis of Students' Mathematical Representation Ability on Phythagoras Theorem in Junior High School

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Abstract: Mathematical representation includes the process of transforming problems or ideas into new forms, including changing pictures or physical models into symbols, words, or sentences that can facilitate students in solving mathematical problems. Pythagorean Theorem material is widely used in analytic geometry, so this material becomes important for students in understanding geometric concepts which makes this material a prerequisite material. Therefore, the purpose of this research is to describe the ability of students' mathematical representations in solving mathematical problems in the Pythagorean theorem material. The research method used in this study was qualitative with the subject of the research being class IX students at one of the junior high schools in Bandung City, totaling 28 people. From the research that has been done, it is concluded that the description of the most dominant mathematical representation ability lies in the low ability of students to present mathematical ideas contained in the problem in the form of image representation so that students are not facilitated in solving a problem presented. In addition, there are still students who experience errors in solving problems involving arithmetic symbols (symbolic representation). In answering questions related to contextual problems, there are still students who have not been able to optimally use representations to model and interpret mathematical phenomena.

Keywords: Mathematical Representation Ability, Pythagorean Theorem.

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Introduction

The National Council of Teacher Mathematics (NCTM) in the book Principles and Standards for School

Mathematics explains that mathematical representation skills are one of the five standard abilities that students must have in learning mathematics (NCTM, 2000). Abstract mathematical concepts require students' access to mathematical ideas and can only be done through the representation of these ideas (Sari & Rosjanuardi, 2018). In line with this opinion, NCTM defines representation as the translation of a problem or idea in a new form, including images or physical models into symbols, words or sentences. Based on the explanations of several researchers above, it can be seen that representation includes the activity of transforming problems or ideas into new forms, including changing images or physical models into symbols, words or sentences. In relation to mathematics, Goldin (2020) in his study explains that mathematical representation is a configuration of visible or real forms or arrangements - such as diagrams, number lines, graphs, written words, mathematical expressions, formulas and equations, which represent ideas. or mathematical relationships. Furthermore, Minarni et al (2016) divide mathematical representation into two parts, namely visual representation which includes graphs, tables, sketches/drawings and non-visual representation including numerical representation, mathematical equations or mathematical models. Thus, representation becomes a very important part of learning mathematics as one of the abilities that refers to the formation of abstractions and demonstrations of mathematical knowledge, as well as illustrations of mathematical problem solving situations. This is reinforced by the statement of Supandi et al (2020) which states that mathematical representation allows students to solve abstract mathematical problems into real ones. Mathematical representation must be emphasized in the mathematics learning process because students' ability to represent problems can help them in solving mathematical problems (Santia et al, 2019).

Fitrianingrum and Basir (2020) in their research show that mathematical representation skills are very important and needed by students in understanding the material given and solving problems. If mathematical representation skills are lacking it causes a lack of students' understanding of the material given so that students find it difficult to understand and work on it. the questions given. Dahlan & Juandi (2011) added that the importance of representation in mathematics learning for students is as a foundation or basis for how students are able to understand and use mathematical ideas in solving a problem. In line with this opinion, Sari & Darhim (2020) in their study explain that representation does not only refer to the results or products of new construction, but involves the thinking process carried out to capture and understand concepts that are used as reasoning tools to express mathematical concepts and ideas. . Thus, mathematical representation includes the thinking process carried out in capturing and understanding various mathematical concepts in an effort to find solutions to realistic mathematical problems through modeling. This mathematical representation ability must be positioned as an important element in strengthening students' understanding of mathematical concepts, communicating approaches, arguments and mathematical understanding to themselves or others.

Research conducted by Yuanita et al (2018) found that mathematical representations have an important role, namely as a mediator between mathematical beliefs and solving arithmetic problems. Research conducted by Mustangin et al (2020) also found that students who have high representation will be able to complete algebra through verbal representation, symbolism, imagination and formal notation which can lead students to solve mathematical problems starting from analyzing, understanding, to concluding to obtain results. correct.

Mathematical representation plays a role in improving students' understanding of mathematical concepts and solving mathematical problems (Supandi et al., 2018). Based on the explanation that has been given, the researcher considers that mathematical representation skills are important to develop because these abilities encourage students to solve mathematical problems.

The results of an international survey conducted by the 2018 Program for International Student Assessment (PISA) on Indonesian students aged 15 years, show that the results for Indonesian students' mathematics scores are still relatively low, namely ranking 73 out of 78 countries evaluated (OECD, 2019). The 2018 PISA study also shows that students in Indonesia scored lower than the OECD average, namely getting a mathematics score of 379 compared to the average international study score of 489. The results of Indonesian students' mathematics scores in the 2015 PISA study were also not much different, namely ranking 63 of 69 participating countries (OECD, 2016). These results show that Indonesian students' mathematics scores based on international studies are still not satisfactory. In connection with the above, PISA questions using non-routine questions very often involve representations of mathematical objects and situations (OECD, 2014). This shows that Indonesian students' mathematical representation abilities are still low. The low ability of students is caused by a lack of representation of students' mathematical understanding, which results in a lack of ideas for mathematical problems. The lack of ideas in mathematical problems results in a lack of translation of these ideas into the form of mathematical objects.

Mathematical representation standards set by NCTM (2000) consist of, 1) creating and using representations to organize, record, and communicate mathematical ideas; 2) select, apply, and translate mathematical representations to solve problems; and 3) using representations to model and interpret physical, social and mathematical phenomena. Meanwhile, Goldin (2020) states that representation consists of internal and external representations. Goldin (2020) further explained that internal representation is difficult to observe directly because it is a person's mental activity in his mind. However, internal representations can be inferred or inferred based on external representations which are the result of manifestations presented in the form of words, symbols, images, graphs, tables or through visual aids. In other words, there is a reciprocal relationship between a person's internal and external representations when dealing with a problem.

One of the mathematical problems that requires mathematical representation skills is algebra (Khairunnisak et al, 2021). The Pythagorean Theorem is one of the algebra materials that uses a lot of mathematical representations in solving problems. The form of mathematical representation used in this material is related to the activity of re-presenting data or information from a symbol representation/mathematical expression to an image representation or vice versa, and using representation to model and interpret contextual problems related to the Pythagorean theorem. Therefore, teachers must develop students' mathematical representation abilities in studying the Pythagorean theorem as an effort to improve students' understanding and learning outcomes. The Pythagorean Theorem is also widely used in analytical geometry, so this material is very important. Therefore, understanding of the concept of the Pythagorean theorem must also be improved.

Based on the previous explanation, it is clear that the Pythagorean theorem is one of the materials that involves various mathematical representations in solving problems. For this reason, it is important to examine and describe students' mathematical representation abilities in the Pythagorean theorem material so that it can become a reference for teaching staff in improving learning practices that are able to develop mathematical representation abilities. The problem formulation that will be looked at in this research is how students' mathematical representation abilities are in solving problems related to the Pythagorean theorem material?

Method

The research method used in this research is descriptive qualitative. This method is used because the research objective is to describe events or experiences and seek in-depth knowledge about the phenomenon being studied (Kim et al., 2017). This research aims to describe students' mathematical representation abilities in the Pythagorean theorem material. The subjects in this research were 28 students in class IX of one of the junior high schools in Bandung City. The object of this research is students' mathematical representation abilities on the Pythagorean theorem material. The data collection technique used is a test technique with a data collection instrument, namely a test instrument in the form of a description test consisting of 4 description questions which have been adapted to indicators of mathematical representation ability. The indicators of mathematical representation ability that are reviewed in this assessment are the three indicators stated by NCTM (2000) as follows:

1. Find and use representations to organize, record, and communicate mathematical ideas.
2. Select and apply mathematics to solve problems.
3. Using representations to model and interpret physical, social and mathematical phenomena.

Data analysis techniques are a way of managing research data to obtain research conclusions. Qualitative data analysis involves organizing, recording and explaining data; in short, understanding data based on participants' definition of the situation, noting patterns, themes, categories and regularities (Cohen et al., 2007). The statistics used to analyze data are carried out by describing the data that has been collected as it is and does not intend to make general conclusions or generalizations. The steps used to carry out data processing are analyzing students' answers based on indicators of mathematical representation ability that have been prepared for each question. The data analysis stages used are data reduction, data presentation and drawing conclusions.

Results

This research was carried out on October 26 2022 in class IX B at one of the junior high schools in the city of Bandung in the odd semester of the 2022/2023 academic year who had studied the material on the Pythagorean theorem.

The following presents data on the results of tests on the ability to mathematically represent material on the Pythagorean theorem which is based on research that has been carried out:

Table 1. List of Acquired Mathematical Representation Ability Test Scores

No	Respondent Code	Score	Value	No	Repondent Code	Score	Value
1	TS	36	60	15	JA	42	70
2	SSZ	44	73	16	RPH	39	65
3	SR	37	62	17	RR	49	82
4	NZG	36	60	18	ZNPP	41	68
5	RSF	37	62	19	HF	45	75
6	WM	49	82	20	MTS	42	70
7	VR	31	52	21	DM	44	73
8	FCS	37	62	22	TN	39	65
9	RF	37	62	23	AMPS	49	82
10	SN	37	62	24	HLJ	34	57
11	SB	37	62	25	BA	44	73
12	DD	36	60	26	HSR	39	65
13	NA	39	65	27	MADR	31	52
14	MAT	34	57	28	RM	39	65

The indicator of mathematical representation used in questions number 1 and 2 is finding and using representation to organize, record and communicate mathematical ideas. Indicator question number 1 is given two measurements of the length of the sides of a right triangle, students can restate data or information from representation to image representation. Meanwhile, in indicator question number 2, several pictures of right-angled triangles are given along with the dimensions of the sides. Students can present picture representations and representations of mathematical expressions that represent these pictures. Based on the review that was carried out on the results of students' answers, the researchers found several findings as follows: 1) Students were not precise in placing the corner points in the triangle drawings they made so they made mistakes in writing the sizes of the sides of the triangle, 2) Students were not perfect in representing the sizes of the sides. - the sides of the triangle in the picture correspond to the size of the side given, 3) Students do not show the picture/symbol of a right angle in the triangle picture they make, 4) Students make a mistake in presenting the image representation as a representation of a mathematical expression.

The mathematical representation indicator used in question number 3 is choosing and applying mathematics to solve the problem. Meanwhile, the problem indicator presents contextual problems related to the Pythagorean theorem, students can solve them by applying the concept of the Pythagorean theorem. Based on the results of the study of students' answers, several findings were found as follows: 1) students experienced errors in presenting questions in the form of pictorial representations, 2) students were less precise in constructing mathematical expressions that represent their pictorial representations, and 3) Students were less precise in

applying algebraic operations to solve the problem.

The mathematical representation indicator used in question number 4 is using representation to model and interpret physical, social and mathematical phenomena. Meanwhile, in the question indicators, contextual problems related to mathematical phenomena in the Pythagorean theorem material are presented, students can solve them by modeling these problems into mathematical expressions. Based on the results of reviewing students' answers, there were students who experienced errors in presenting problems in the form of pictorial representations and students were correct in presenting problems in pictorial form but did not complete the results.

Discussion

Indicator 1

Students are not precise in placing the corner points in the triangle drawing they make so they make mistakes in writing the dimensions of the sides of the triangle.

There were 14 students who were incorrect in placing the corner points in the triangle image they had created. This shows that there are errors experienced by students in constructing information/reading into the form of pictorial representation. Below are several variations of student answers:

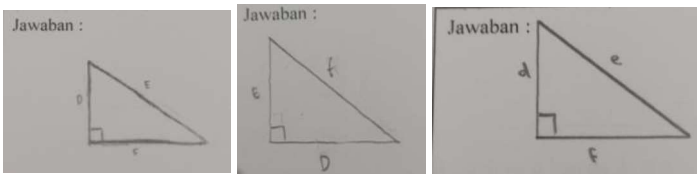

Figure 1. Display of TS, SSZ, and RR Answers to Question Number 1

There are errors in the answers to TS, SSZ, and RR due to students' lack of understanding about corner points. So TS, SSZ, and RR cannot state/write the size of the sides of the triangle in the image. The researcher assessed that the student did not understand the main keyword "Rangular at point E" in the question which is the first step in drawing a right triangle correctly. The three students above looked at the given corner point as a measure of the length of the side of the triangle. Apart from that, there were 4 students who experienced errors in placing the side sizes according to the information provided. This shows that there are errors experienced by students in constructing information/reading into the form of pictorial representation.

Students are not perfect in representing the sizes of the sides of a triangle in the picture that correspond to the sizes of the sides given

There were 21 students who were not correct in drawing a right triangle because they did not adjust the size of the sides of the triangle in accordance with the information in the question. This shows that there is a mismatch

between the sizes of the sides of the triangle so that the representation is not perfect. Below are several variations of student answers for this case:

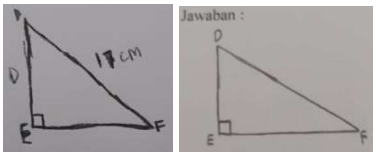

Figure 3. Display of VR and SR Answers to Question Number 1

The VR and SR answers do not show a significant difference in side size between side DF = 17 cm and side DE = 8 cm. The researcher assessed that the student did not focus on paying attention to the sizes of the known sides so that the representation created truly reflected the information provided.

Students do not show the picture/symbol of a right angle in the triangle picture they make

There were 3 students who did not include the right-angled symbol/sign in the right-angled triangle drawing they had made. This will at least affect students' understanding of the Pythagorean theorem material which only applies to right triangles. The following are presented students' answers to this case:

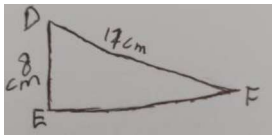

Figure 4. Display of MTS Answers to Question Number 1

The MTS answer does not include signs/symbols from right angles, so the image presented does not form a perfect representation.

Students mistakenly present picture representations to represent mathematical expressions.

There were 8 students who experienced errors in writing mathematical expressions in the form of algebraic expressions of the Pythagorean theorem based on the picture of the right triangle presented. Below are some answers from students who experienced errors in stating the Pythagorean theorem:

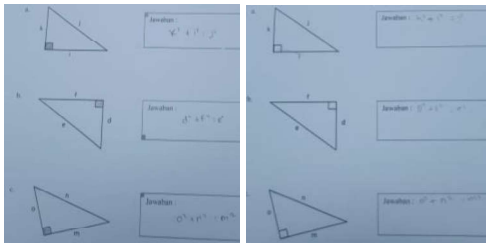

Figure 4. Display of ZNPP and MADR Answers to Question Number 2

ZNPP and MADR answers were correct in questions number 2a and 2b but had an error in presenting the Pythagorean theorem in question number 2c. The researcher assessed that the two students had difficulty interpreting the sides of a triangle when presented in an unusual position. Therefore, students have not been able to properly interpret the Pythagorean theorem, where in any position we can still determine the longest side of a right triangle or on the other hand, students can first determine the sides of the right angle.

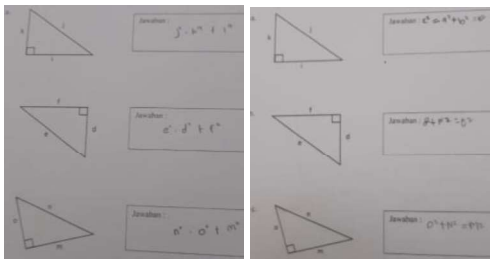

Figure 5. Display of NA and VR Answers to Question Number 2

The NA and VR answers have errors, especially in question number 2a. NA presents an answer which does not represent the Pythagorean theorem which states the square of the sides of a right triangle and is not the measure of the side of a right triangle raised to the power of any number a. Meanwhile, VR in number 2a presents the answer to the Pythagorean theorem, the expression of which is commonly used in various learning sources, which does not correspond to the dimensions of the sides of the right triangle known in the problem.

The four findings above in questions number 1 and 2 indicate that some students do not have a complete understanding of the concept of right triangles. Judging from the indicators of mathematical representation ability, it can be seen that there is a relationship with the appearance of students' answers who are unable to understand the concept of right angles in triangles which are then not perfectly represented in the form of pictures. As stated by Hwang, et al. (2007) that students who are accustomed to listening and listening to what the teacher explains about mathematical material will not be enough to be able to build problem representations. Apart from that, researchers assess that students still experience errors in presenting an image representation to represent a mathematical expression that represents it. The cause of errors lies in students' lack of understanding of the concept of the Pythagorean theorem so that the concept is limited to only certain cases. The name "hypotenuse" in the Pythagorean theorem that students understand can distort their understanding if they are presented with an unusual right triangle shape. This indicates that the name "hypotenuse" is not appropriate in the Pythagorean theorem that is understood by students. Furthermore, the researcher offers the name "longest side" which was previously understood as the "hypotenuse" of a right triangle.

Mawaddah and Maryanti (2016) stated that knowledge will stick around longer if students are directly involved in the process of understanding and constructing concepts and knowledge themselves. This was also confirmed by Ruswana and Zamnah (2018) who stated that when studying, most students use a memorization system rather than discovering the concept of the material, which will cause them to often forget and use it incorrectly. Based

on previous explanations, researchers assess that students still experience problems in organizing, recording and communicating mathematical ideas which can be presented in the form of pictorial representations or vice versa. This explanation also indicates that students in indicator 1 are still not optimal regarding visual representation and symbolic representation.

Indicator 2

Based on the results of the review of students' answers, there were 2 students who experienced errors in presenting problems in the form of pictorial (visual) representations, 4 students were incorrect in compiling mathematical expressions that represent the pictorial representations that had been created, and 24 students were incorrect in applying algebraic operations (symbolic representation) in solving problems. Below are several displays of students' answers who experienced errors in stating the Pythagorean theorem:

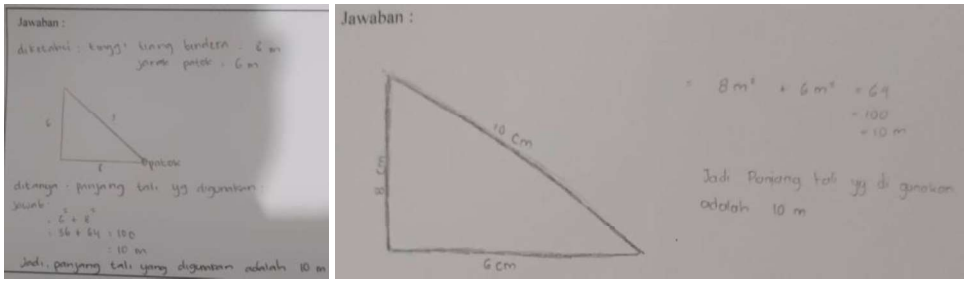

Figure 6. Display of RPH and TS Answers to Question Number 3

RPH experienced errors in presenting problems in the form of pictorial (visual) representations because they did not fully understand the problem. Therefore, the mathematical ideas contained in the problems cannot be transformed into images that can accompany students in solving problems. Meanwhile, TS students are not precise in compiling mathematical expressions that represent the image representation that has been created. Therefore, the mathematical expression that states the Pythagorean theorem does not represent the image that has been created.

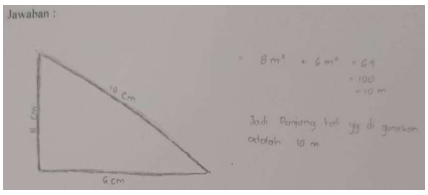

Figure 7. Display of TS Answers to Question Number 3

TS students are not precise in compiling mathematical expressions that represent the image representations that have been made. Therefore, the mathematical expression that states the Pythagorean theorem does not represent the image that has been created.

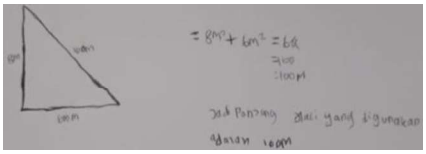

Figure 8. Display of VR Answers to Question Number 3

VR does not appropriately apply algebraic operations in solving Pythagorean theorem problems. Based on Figure 8, it can be seen that students' mistakes lie in their lack of mastery of the concepts of roots and exponents. Therefore, mathematical expressions that are initially presented well but obtain incorrect results due to inappropriate algebraic operations.

Based on the 3 cases above, students were still found to experience errors in choosing and applying mathematics to solve problems. According to Leite et al (2014), practice questions related to contextual problems require students to have great abstraction skills, especially to understand the problem, retrieve data, and then carry out the necessary calculations. Leite et al (2014) further stated that it should be noted that a student's ability to carry out mathematical calculations is not enough to solve the problem: he must reflect on the problem description, retrieve the correct data, identify the concepts involved and finally calculate the answer. This explanation indicates again that the visual and symbolic representation of junior high school students is still not optimal.

Indicator 3

Based on the results of reviewing students' answers, there were 9 students who experienced errors in presenting the problem in the form of pictorial representation (visual), 4 students were correct in representing the problem in pictorial form but did not finish getting the results, and the rest presented the correct representation so they found the right answer. The following displays several student answers:

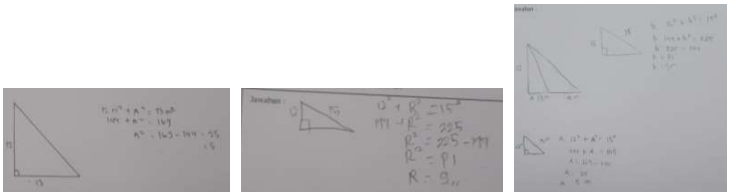

Figure 9. Display of RSF, MAT, and HLJ Answers to Question Number 4

RSF, MAT, and HLJ students experienced errors in presenting problems in the form of pictorial (visual) representations because they did not understand the questions completely. Therefore, the mathematical ideas contained in the problems cannot be transformed into images that can accompany students in solving problems.

SR and RF students were correct in representing the mathematical ideas stated in the questions well. However, the two students were unable to solve this problem completely. This is because students do not understand the

questions completely, so they cannot interpret the questions in the pictures that have been presented.

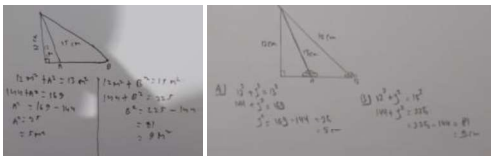

Figure 10. Display of SR and RF Answers to Question Number 4

Based on the explanation of the answers above, it is still found that students experience difficulties in using representations to model and interpret physical, social and mathematical phenomena. In relation to this problem, students are not able to present the mathematical ideas contained in the problem in the form of images that can lead students in solving a problem. Several previous research findings show that students who have problems with pictorial representation experience difficulty in constructing, showing the process and results of mathematical solutions (Surya, Sabandar, Kusumah, & Darhim, 2013). Most students do not have comprehensive abilities in solving problems, students have weaknesses in visual representation, students think it is not important to make graphs, they only think about how to use formulas to solve problems (Minarni, Napitupulu, & Husein, 2016).

Conclusion

The problem formulation in this research concerns the errors or mistakes experienced by students in solving Pythagorean theorem problems related to mathematical representation abilities. From the research that has been conducted, we conclude that the most dominant low ability in mathematical representation lies in students' ability to present mathematical ideas contained in problems in the form of pictorial representations. Apart from that, students were still found who experienced errors in solving problems involving arithmetic symbols (symbolic representation). This is shown by students not accurately transforming image representations into symbolic representations or mathematical expressions that represent them. The lack of precise presentation of visual representations and symbolic representations has an impact on students not being facilitated in finding solutions to the problems presented. In answering questions related to contextual problems, there are still students who are not able to optimally use representations to model and interpret mathematical phenomena.

Recommendations

The suggestion that researchers can make regarding the findings of this research is that in further research they can develop an integrated learning design to improve students' mathematical representation abilities on the Pythagorean theorem material. Apart from that, it is hoped that further research can apply learning methods/models/strategies that are suitable for mathematics learning and can improve mathematical representation abilities in Pythagorean theorem material.

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